

WHAT IS CLAIMED IS:

1. A method for generating hydrogen, the method comprising the steps of:
 - 5 reforming a hydrocarbon fuel in a first catalyst bed comprising a reforming catalyst and a carbon dioxide fixing material at a reforming temperature to produce a reformate comprising hydrogen and at least one impurity selected from the group consisting of carbon monoxide, carbon dioxide, and unreacted hydrocarbon fuel, the carbon dioxide fixing material fixing at least a portion of the carbon dioxide in the reformate to produce a hydrogen-rich reformate and fixed carbon dioxide;
 - 10 monitoring the amount of hydrogen or the least one impurity in the reformate;
 - 15 calcinating the carbon dioxide fixing material within the first catalyst bed at a calcination temperature to release the fixed carbon dioxide; and hydrating the calcinated carbon dioxide fixing material with steam when the monitored amount of hydrogen or the at least one impurity in the reformate is at a predetermined level.
- 20 2. The method of claim 1, wherein hydrogen is monitored and the predetermined level is less than about 97%.
3. The method of claim 2, wherein the predetermined level is less than about 95%.
- 25 4. The method of claim 3, wherein the predetermined level is less than about 92%.
5. The method of claim 1, wherein the at least one impurity is carbon dioxide and the predetermined level is greater than about 0.5%.
- 30 6. The method of claim 5, wherein the predetermined level is greater than about 1%.

7. The method of claim 6, wherein the predetermined level is greater than about 1.5%.
8. The method of claim 1, wherein the at least one impurity is carbon monoxide and the predetermined level is greater than about 5 ppm.
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9. The method of claim 1, wherein the predetermined level is greater than about 15 pm.
10. The method of claim 1, wherein the predetermined level is greater than about 25 ppm.
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11. The method of claim 1, wherein the at least one impurity is unreacted hydrocarbon fuel and the predetermined level is greater than about 0.75%.
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12. The method of claim 11, wherein the predetermined level is greater than about 1%.
13. The method of claim 11, wherein the predetermined level is greater than about 1.5%.
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14. The method of claim 1, further comprising the step of calcinating a carbon dioxide fixing material within a second catalyst bed at a calcination temperature to release fixed carbon dioxide while reforming the hydrocarbon fuel in the first catalyst bed.
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15. A method for generating hydrogen, the method comprising the steps of:
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 - performing two or more reforming/calcinating cycles, each
 - reforming/calcinating cycle comprising (a) reforming a hydrocarbon fuel in a catalyst bed comprising a reforming catalyst and a carbon dioxide fixing material to produce a reformat comprising hydrogen and carbon dioxide, the carbon dioxide fixing material fixing at least a portion of the carbon dioxide in the reformat to produce a hydrogen-

rich reformate and fixed carbon dioxide; and (b) calcinating the carbon dioxide fixing material within the catalyst bed to release fixed carbon dioxide; and

5 hydrating the calcinated carbon dioxide fixing material with steam after performing the two or more reforming/calcinating cycles.

16. The method of claim 15, further comprising the step of performing one or more reforming/calcinating cycles after hydrating the calcinated carbon dioxide fixing material.

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17. The method of claim 15, further comprising the step of allowing the catalyst bed to cool to a shut down temperature after hydrating the calcinated carbon dioxide fixing material.

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18. A method for generating hydrogen, the method comprising the steps of:
calcinating a carbon dioxide fixing material within a first catalyst bed at a
calcination temperature to release fixed carbon dioxide, the first catalyst
bed comprising the carbon dioxide fixing material and a reforming
catalyst;

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hydrating the calcinated carbon dioxide fixing material with steam at
hydration temperature below a reforming temperature; and
heating the first catalyst bed to the reforming temperature.

19. The method of claim 18, wherein the hydration temperature is below 600°C.

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20. The method of claim 18, wherein the reforming temperature is between about
400°C and about 800°C.

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21. The method of claim 20, wherein the reforming temperature is between about
450°C and about 700°C.

22. The method of claim 21, wherein the reforming temperature is between about
500°C and about 650°C.

23. The method of claim 18, wherein the calcination temperature is above about 550°C.

5 24. The method of claim 23, wherein the calcination temperature is above about 650°C.

25. The method of claim 24, wherein the calcination temperature is above about 750°C.

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26. The method of claim 18, further comprising the step of performing one or more reforming/calcinating cycles after heating the catalyst bed to the steam reforming temperature, each reforming/calcinating cycle comprising (a) reforming a hydrocarbon fuel in the first catalyst bed to produce a reformate comprising hydrogen and carbon dioxide, the carbon dioxide fixing material fixing at least a portion of the carbon dioxide in the reformate and (b) calcinating the carbon dioxide fixing material within the catalyst bed to release fixed carbon dioxide.

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20 27. The method of claim 18, further comprising the step of reforming a hydrocarbon fuel in a second catalyst bed comprising a reforming catalyst and a carbon dioxide fixing material to produce a reformate comprising hydrogen and carbon dioxide while calcinating the carbon dioxide fixing material in the first catalyst bed.

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28. A method for continuously converting hydrocarbon fuel to a hydrogen-rich reformate, the method comprising the steps of:
reforming a hydrocarbon fuel in a first catalyst bed comprising a reforming catalyst and carbon dioxide fixing material at a reforming temperature to produce a hydrogen-rich reformate, the carbon dioxide fixing material fixing at least a portion of the carbon dioxide in the hydrogen-rich reformate to produce a hydrogen-rich reformate and fixed carbon dioxide;

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calcinating a carbon dioxide fixing material in a second catalyst bed comprising a reforming catalyst and carbon dioxide fixing material by heating the carbon dioxide fixing material to a calcination temperature above the reforming temperature; and

5 hydrating the calcinated carbon dioxide fixing material in the second catalyst bed with steam at a hydration temperature below the reforming temperature to produce a regenerated carbon dioxide fixing material; wherein hydrocarbon fuel is reformed in the first catalyst bed while the carbon dioxide fixing material is hydrated in the second catalyst bed.

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29. The method of claim 28, further comprising the steps of:

reforming a hydrocarbon fuel in the second catalyst bed at a reforming temperature to produce a hydrogen-rich reformate, the regenerated carbon dioxide fixing material fixing at least a portion of the carbon dioxide in the hydrogen-rich reformate; and

15 calcinating the carbon dioxide material in the first catalyst bed by heating the carbon dioxide fixing material to a calcination temperature above the reforming temperature;

wherein hydrocarbon fuel is reformed in the second catalyst bed while the carbon dioxide fixing material is calcinated in the first catalyst bed.

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30. The method of claim 29, further comprising the step of hydrating the calcinated carbon dioxide fixing material in the first catalyst bed with steam to produce a regenerated carbon dioxide fixing material.

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31. A method for generating hydrogen, the method comprising the steps of:

reforming a hydrocarbon fuel in a catalyst bed comprising a reforming catalyst and a carbon dioxide fixing material at a reforming temperature to produce a reformate comprising hydrogen and carbon dioxide, the carbon dioxide fixing material fixing at least a portion of the carbon dioxide to produce a hydrogen-rich reformate and fixed carbon dioxide;

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calcinating the carbon dioxide fixing material within the catalyst bed at a calcination temperature to release fixed carbon dioxide; and hydrating the calcinated carbon dioxide fixing material with steam at a hydration temperature below the reforming temperature

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32. The method of claim 31, wherein the hydration temperature is below 600°C.

33. The method of claim 31, wherein the hydration temperature is below about 450°C.

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34. The method of claim 33, wherein the hydration temperature is below about 300°C.

35. The method of claim 31, wherein the hydrocarbon fuel is a gas at 30°C.

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36. The method of claim 35, wherein the hydrocarbon fuel comprises a component selected from the group consisting of methane ethane, propane, butane, and mixtures of the same.